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Hoshino et al.

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(54) **KEYBOARD DEVICE AND KEYBOARD INSTRUMENT**

(71) Applicant: **CASIO COMPUTER CO., LTD.**, Tokyo (JP)

(72) Inventors: **Akihisa Hoshino**, Tokyo (JP); **Hirokazu Taniguchi**, Tokyo (JP)

(73) Assignee: **CASIO COMPUTER CO., LTD.**, Tokyo (JP)

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G10C 3/18 (2006.01)
G10C 3/12 (2006.01)
G10H 1/34 (2006.01)

(52) **U.S. Cl.**
CPC . ***G10C 3/18*** (2013.01); ***G10C 3/12*** (2013.01); ***G10H 1/346*** (2013.01)

(58) **Field of Classification Search**
CPC G10C 3/161; G10C 3/18; G10C 3/22; G10H 1/346
See application file for complete search history.

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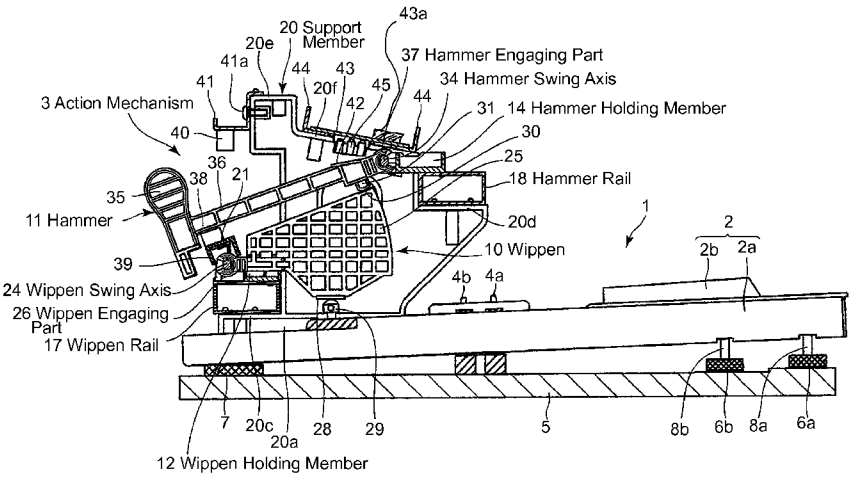
Primary Examiner — Robert W Horn
(74) *Attorney, Agent, or Firm* — Chen Yoshimura LLP

(57) **ABSTRACT**

A keyboard device including a plurality of wippens that respectively rotate in the vertical direction in response to the respective depressions of the plurality of keys aligned alongside each other, a plurality of hammers that swing in response to the respective rotation of the plurality of wippens and then respectively add an action load to the plurality of keys, and a wippen holding member having a plurality of wippen flanges that are integrally formed along a direction in which the keys are aligned and that rotatably hold the respective plurality of wippens. Therefore, the plurality of wippen flanges do not need to be individually manufactured and assembled, and thus the plurality of wippen flanges can be easily disposed at once by just installing the wippen holding member.

18 Claims, 11 Drawing Sheets



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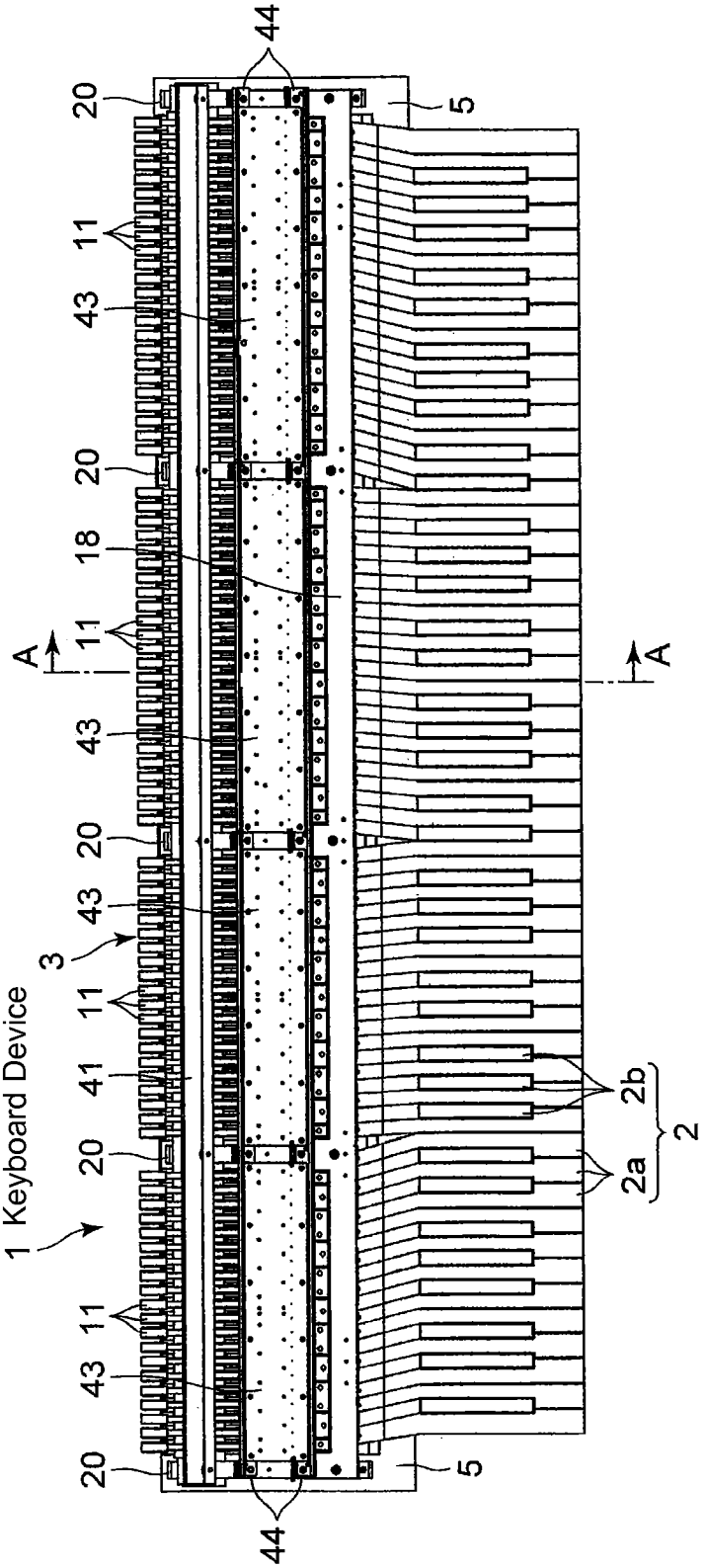


FIG. 1

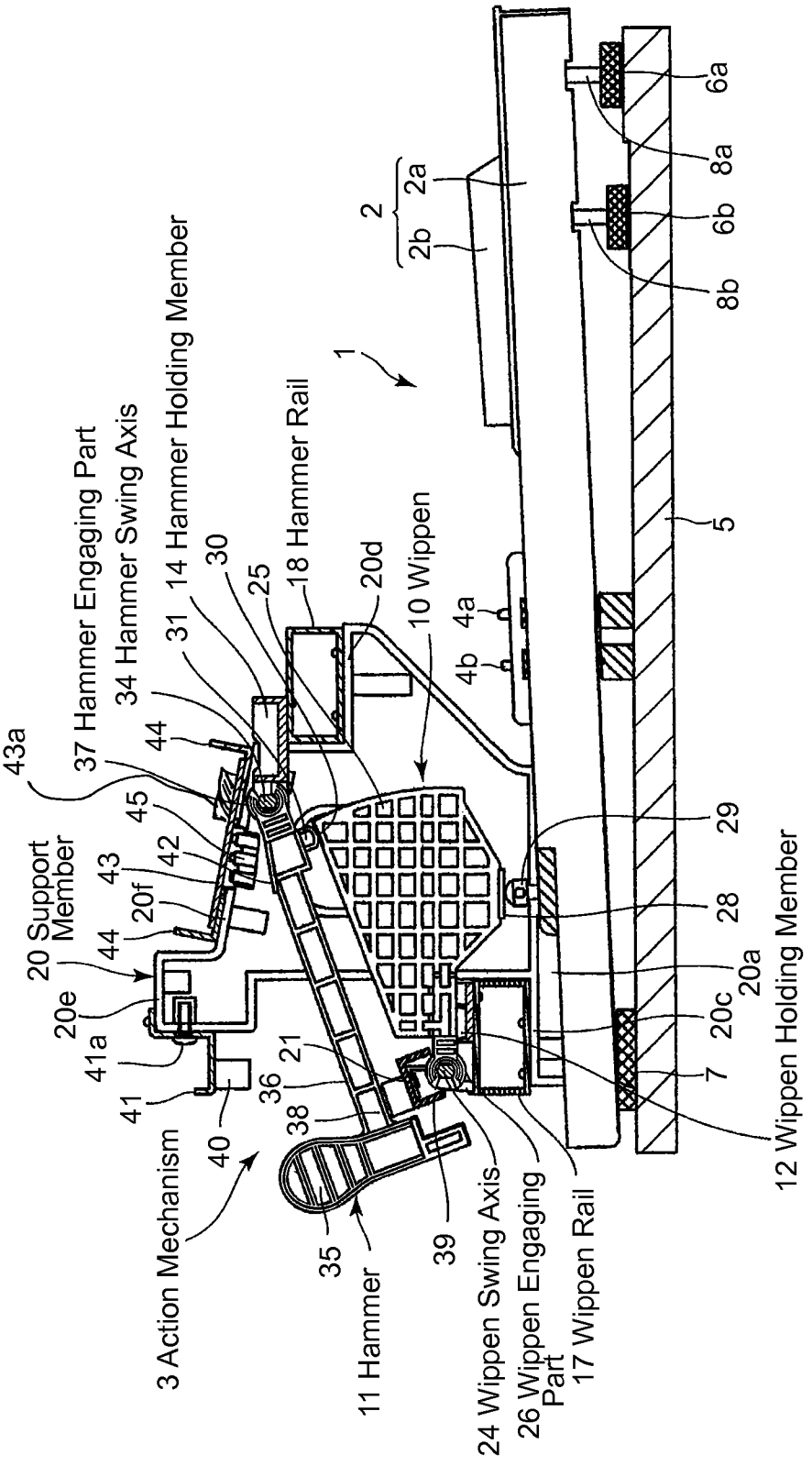
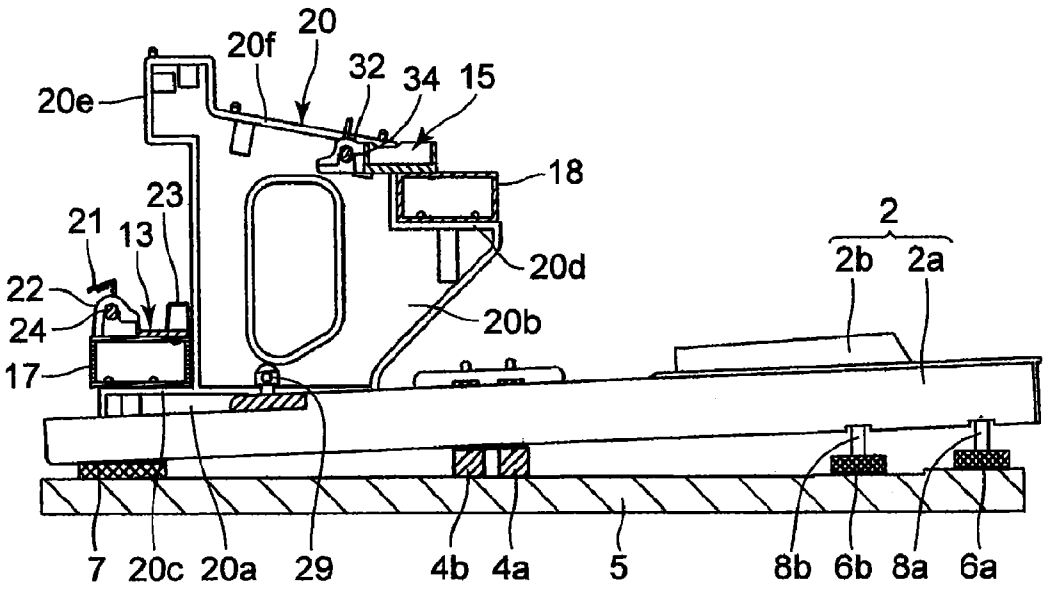

1
2
2a
2b
5
6a
6b
8a
8b
10 Wippen
12 Wippen Holding Member
14 Hammer Holding Member
17 Wippen Rail
18 Hammer Rail
20 Support Member
20a
20c
20d
20e
20f
24 Wippen Swing Axis
25
26 Wippen Engaging Part
28
29
30
31
34 Hammer Swing Axis
35
36
37 Hammer Engaging Part
38
39
40
41
41a
42
43
43a
44
45
3 Action Mechanism
4a
4b
7
11 Hammer
21

FIG. 2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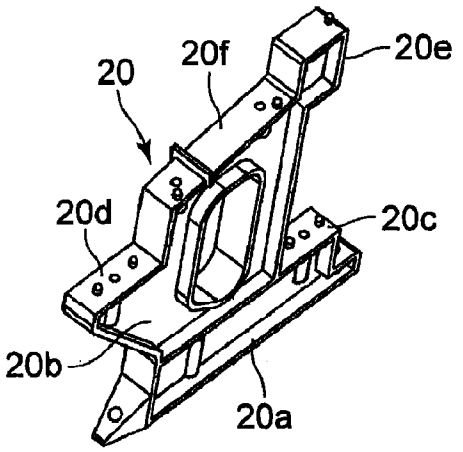
20f
32
34
15
20e
18
23
21
13
2
2b
2a
22
20d
24
20b
17
7
20c
20a
29
4b
4a
5
8b
6b
8a
6a

FIG. 3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20f
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20b
20a

FIG. 4

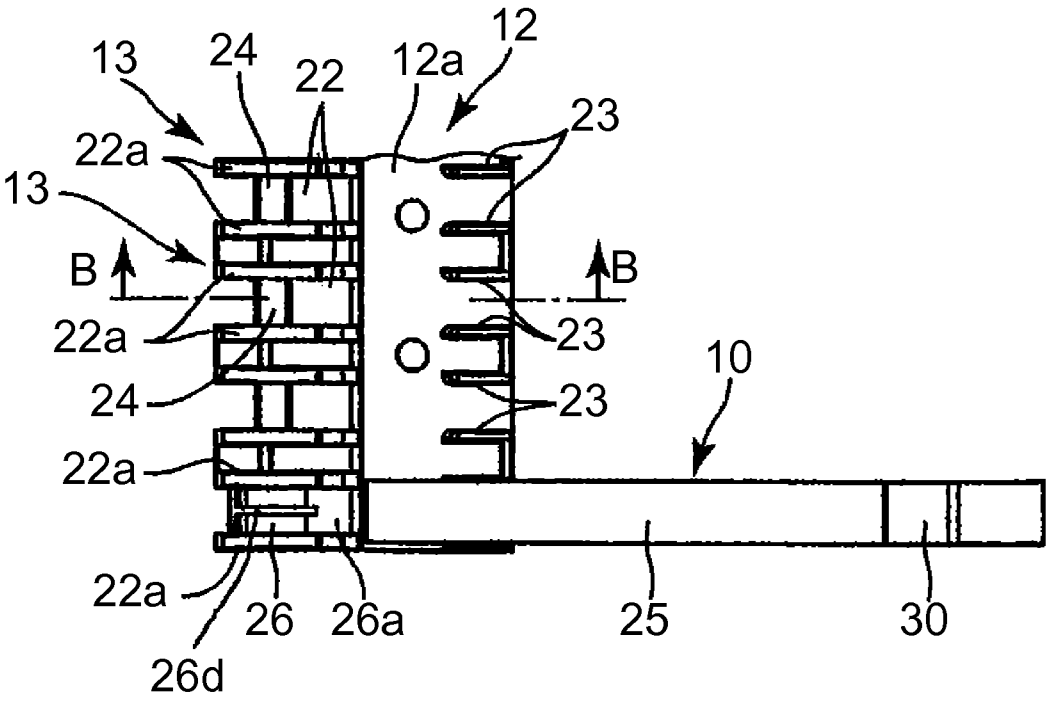

13
24
22
12a
12
23
22a
13
B
B
22a
23
10
24
23
22a
22a
26
26a
25
30
26d

FIG. 5A

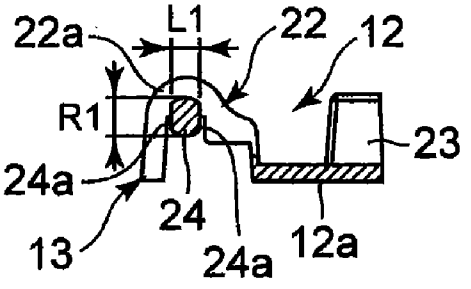
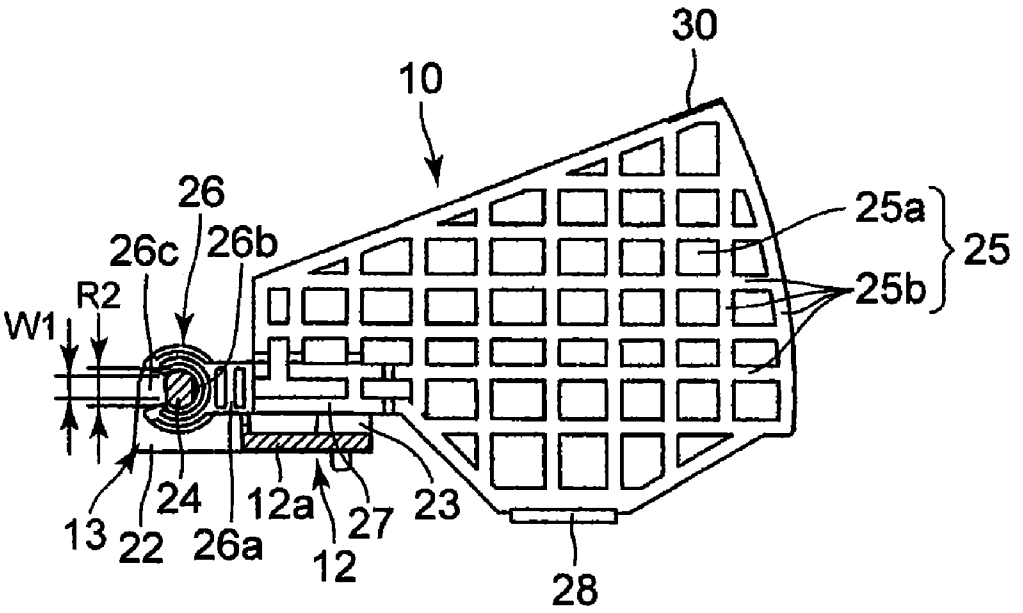

22a
L1
22
12
R1
23
24a
24
13
24a
12a

FIG. 5B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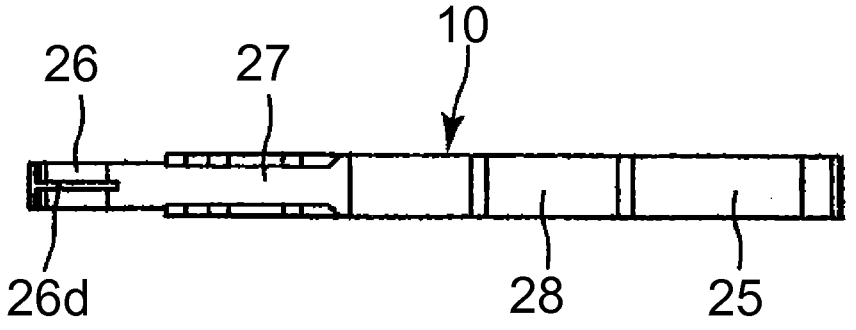
10
26
26c
26b
25a
25
25b
R2
W1
13
22
24
26a
12a
12
27
23
28

FIG. 6A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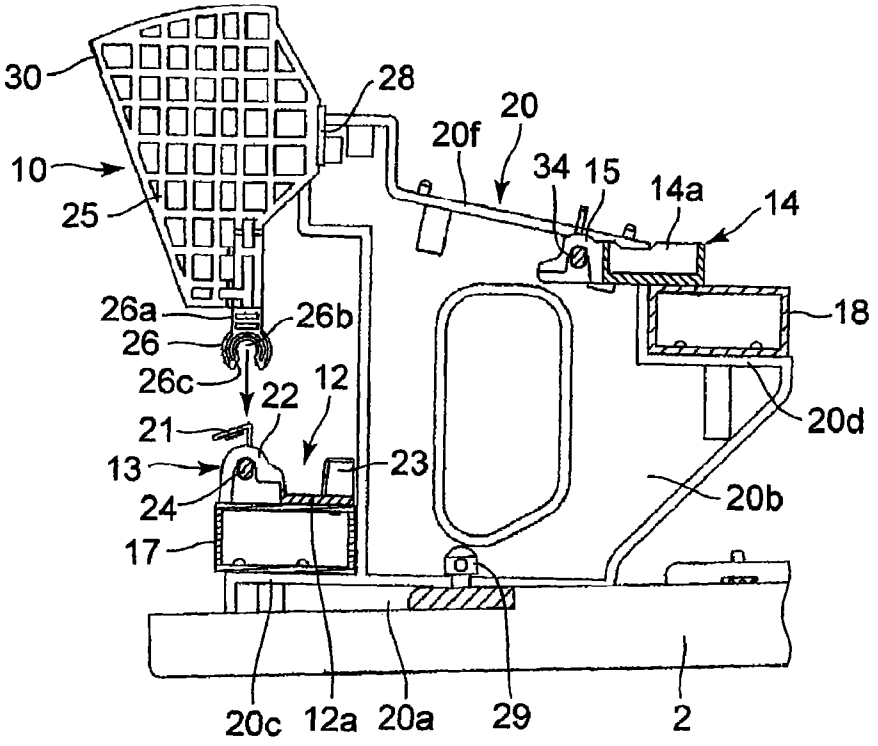
26
27
26d
28
25

FIG. 6B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28
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20f
10
34
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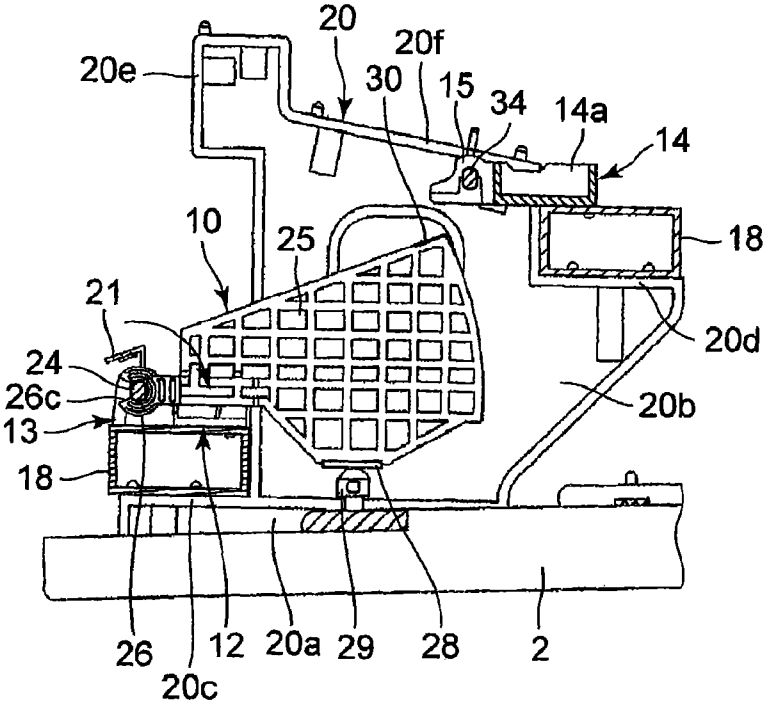
14a
14
25
26a
26b
18
26
26c
22
12
20d
21
13
23
24
20b
17
20c
12a
20a
29
2

FIG. 7A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20e
20f
30
15
34
14a
14
10
25
18
21
20d
24
26c
20b
13
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26
12
20a
29
28
2
20c

FIG. 7B

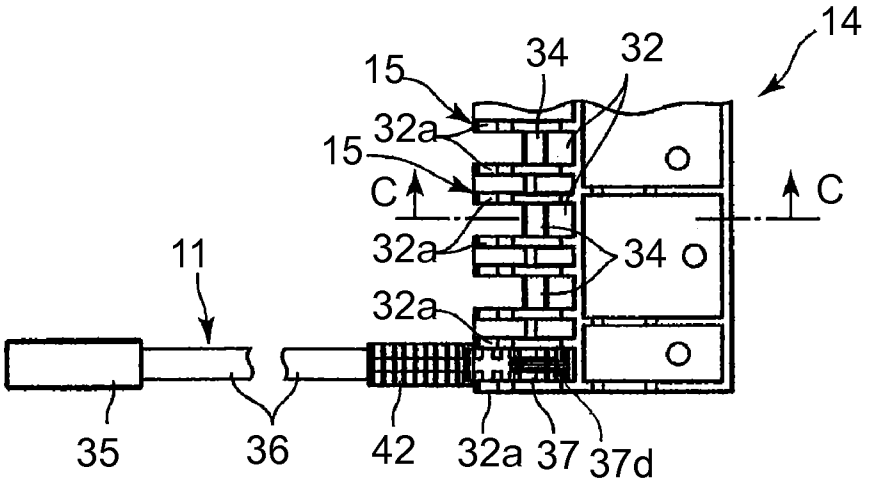

FIG. 8A

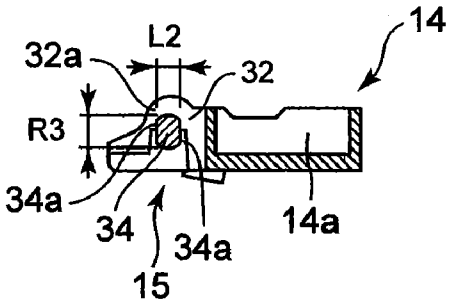

FIG. 8B

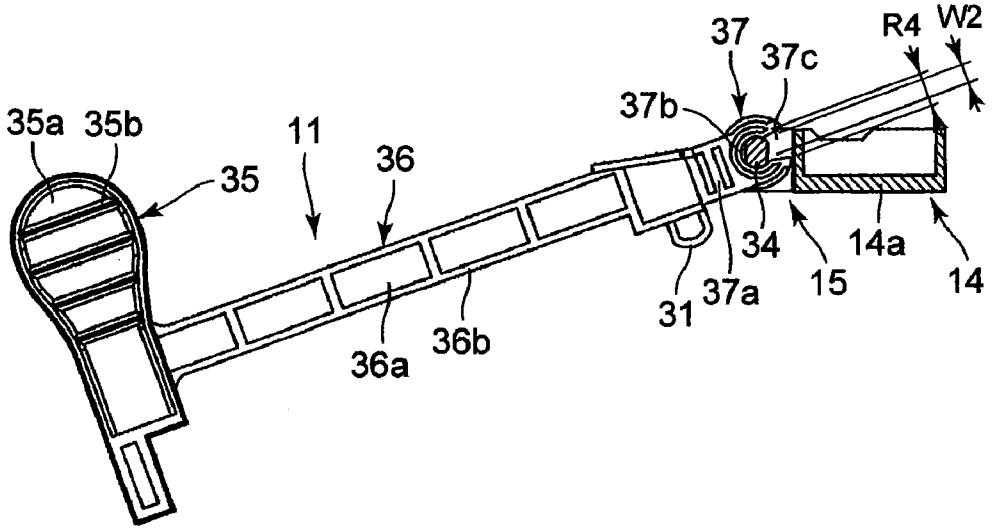

FIG. 9

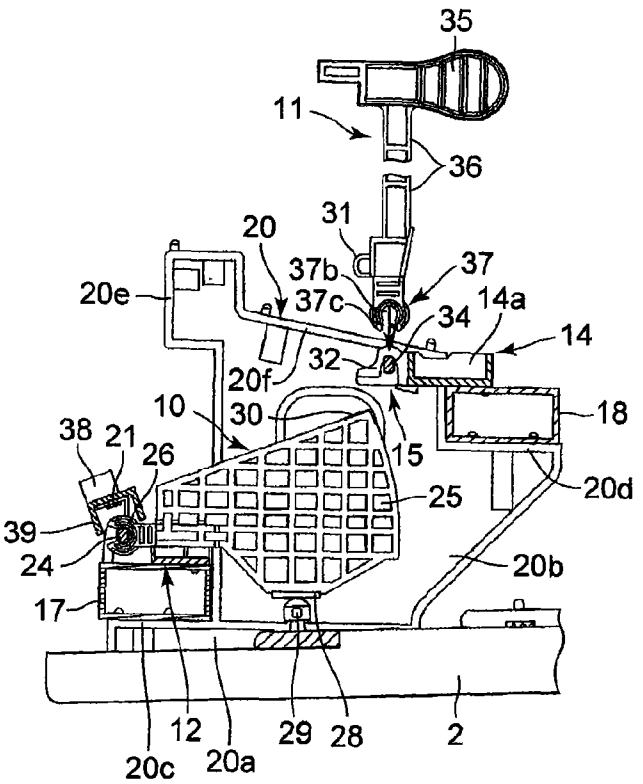

FIG. 10A

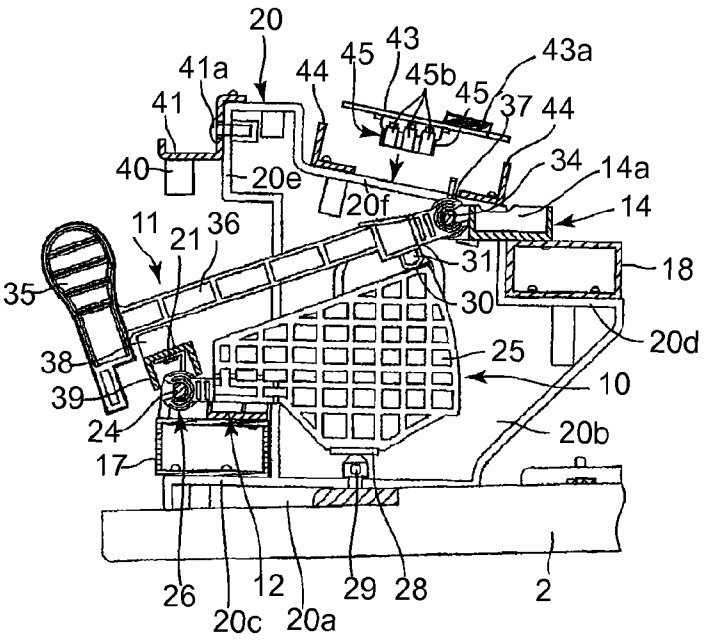

FIG. 10B

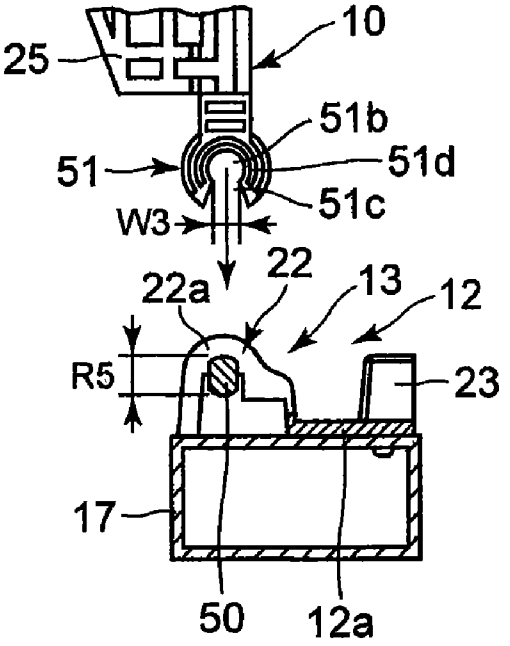

FIG. 11A

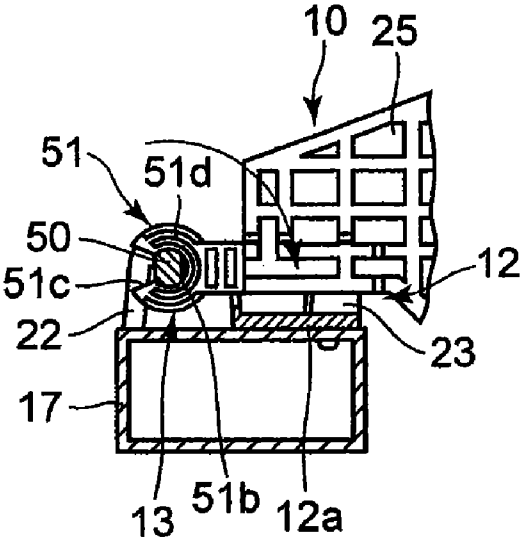

FIG. 11B

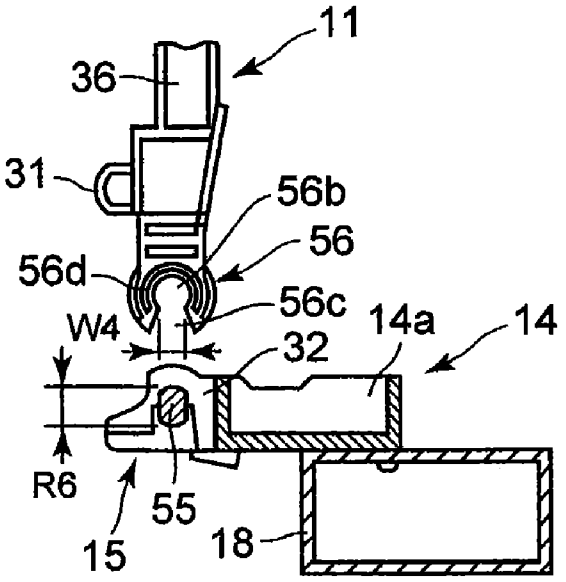

FIG. 12A

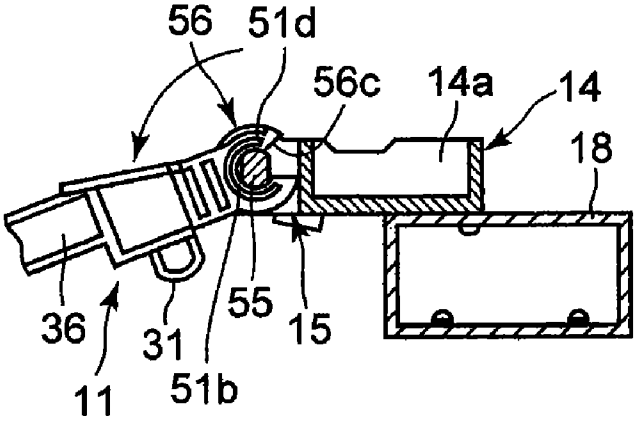

FIG. 12B

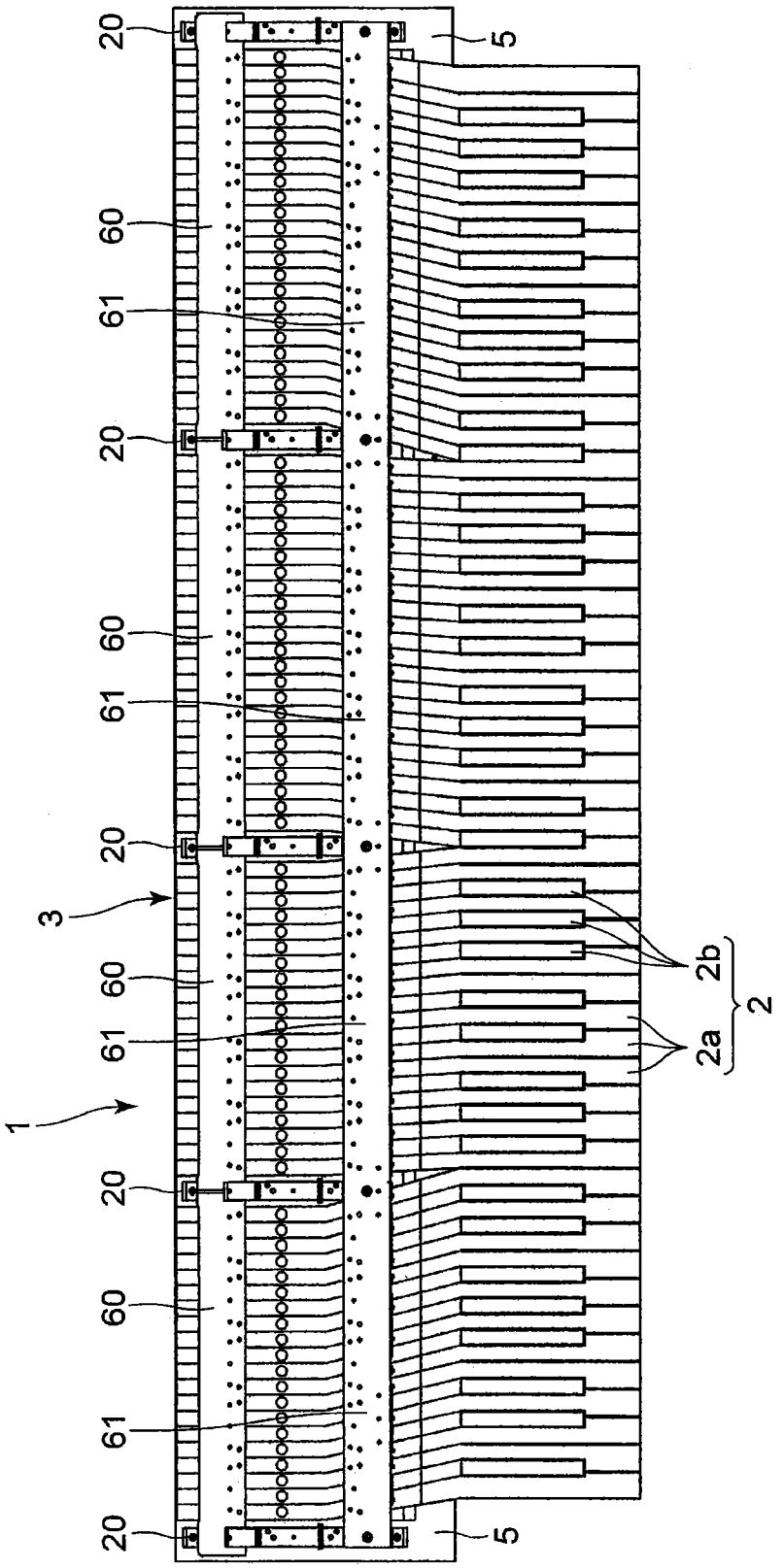

FIG. 13

KEYBOARD DEVICE AND KEYBOARD INSTRUMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of Japanese Patent Application No. 2014-058143, filed Mar. 20, 2014, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Technical Field

This invention relates to keyboards and keyboard instruments such as pianos.

2. Background Art

For example, Japanese Patent Application Laid-Open Publication No. 2002-258835 discloses a keyboard instrument having a structure with a plurality of keys respectively including a wippen that rotates when a key is depressed, a jack that is driven by the wippen swinging, and a hammer that strikes a string after being driven by the jack.

This type of keyboard instrument includes a wippen rail and a hammer rail respectively running the entire length of the plurality of keys in the array direction of the plurality of keys.

A plurality of wippen flanges that corresponds to respective keys are attached to the wippen rail, and a plurality of wippens are respectively attached to the wippen flanges by pins such that the wippens can swing.

A plurality of hammer flanges are respectively attached to the plurality of wippens on the hammer rail. Respective hammer shanks of the plurality of hammers are attached to the hammer flanges with pins such that the hammer shanks can swing.

This type of keyboard instruments needs the wippen to be individually attached to the wippen flange with a pin. Therefore, when the plurality of wippens are being attached to the wippen rail, the plurality of wippens need to be individually attached to the wippen rail one after another according to the attaching procedure for attaching a plurality of wippens. This results in problems such as the assembly process being tedious, productivity being low, and the cost being high.

Furthermore, the hammer of this keyboard instrument needs to be individually attached to the hammer flanges with a pin. Therefore, when a plurality of hammers are being attached to the hammer rail, the plurality of hammer flanges need to be individually attached to the hammer rail one after another. This result in problems such as the assembly process being tedious, productivity being low, and the cost being high.

In addition, recently, applying this type of action that adds a more realistic key touch to electronic keyboard instruments that produce a hammer struck string sound using an electronic sound source circuit is being proposed.

In ordinary electronic keyboard instruments, a switch is provided under each key to detect the depressing and releasing of keys, or the velocity of the key depressing. However, if this type of action is included in such electronic keyboard instruments, a new problem emerges.

That is, the switch provided for each key is a component that receives the most mechanical load when the keys are used, and malfunctions often. As a result, the switch needs frequent repair and replacement. Conventionally, the keys could have been repaired or replaced relatively easily by removing the keys or the like, but if the keyboard has the above-mentioned type of mechanism, repairing and replacing keys becomes more difficult.

In addition, recently, applying this type of action that adds a more realistic key touch to electronic keyboard instruments that produces the hammer struck string sound using an electronic sound source circuit is being proposed. In this case, the usage of resins or the like that has a material property that is lighter and allows higher productivity than regular cast metal is proposed as the material of the bracket, which is a supporting member that supports the hammer and the wippen.

However, the bracket supports the entire action mechanism, and therefore a bracket using resin or the like had insufficient strength compared to conventional brackets made of cast metal.

Furthermore, the keyboard is structured such that the supporting member such as a bracket is supported by a plurality of long rails, and therefore, even if a material that is light and high in productivity such as resin is used, the supporting member such as a bracket can maintain sufficient strength.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a keyboard and a keyboard instrument that is easy to assemble, has good productivity, and can reduce cost.

Additional or separate features and advantages of the invention will be set forth in the descriptions that follow and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims thereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, in one aspect, the present disclosure provides a keyboard device having: a plurality of keys; and a plurality of key action mechanisms respectively provided for the plurality of keys, wherein each of the key action mechanisms includes: a wippen swing axis; a wippen that has a wippen engaging part that swingably couples with the wippen swing axis by being inserted removably to the wippen swing axis, the wippen being coupled to the wippen swing axis so as to swing about the wippen swing axis in response to a depression of the corresponding key; and a hammer that swings in response to the swing of the wippen triggered by the depression of the key so as to apply a load to the key when the key is depressed.

In another aspect, the present disclosure provides a keyboard device having: a plurality of keys; and a plurality of key action mechanisms respectively provided for the plurality of keys, wherein each of the key action mechanisms includes: a wippen that shifts in response to a depression of the corresponding key; a hammer swing axis; a hammer having a hammer engaging part that swingably couples with the hammer swing axis by being inserted removably to the hammer swing axis, the hammer being coupled to the hammer swing axis so as to swing about the hammer swing axis in response to a depression of the key so as to apply a load to the key when the key is depressed.

In another aspect, the present disclosure provides a keyboard device having: a plurality of keys; and a plurality of key action mechanisms respectively provided for the plurality of keys, wherein each of the key action mechanisms

includes: a wippen swing axis; a wippen that has a wippen engaging part that swingably couples with the wippen swing axis by being inserted removably to the wippen swing axis, the wippen being coupled to the wippen swing axis so as to swing about the wippen swing axis in response to a depression of the corresponding key; a hammer swing axis; and a hammer having a hammer engaging part that swingably couples with the hammer swing axis by being inserted removably to the hammer swing axis, the hammer being coupled to the wippen swing axis so as to swing about the hammer swing axis in response to a depression of the key to apply a load to the key when the key is depressed.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory, and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a plan view of an embodiment in which this invention was applied to an electronic keyboard instrument.

FIG. **2** is an enlarged side view along arrow A-A of a keyboard instrument shown in FIG. **1**.

FIG. **3** is an enlarged side view showing the keyboard instrument shown in FIG. **2** having a wippen rail and a hammer rail disposed on a plurality of supporting members across the entire length of a plurality of keys in the key arrangement direction.

FIG. **4** is an enlarged perspective view of a supporting member shown in FIG. **3**.

FIGS. **5**A and **5**B show respective portions of the wippen holding member and the jack, in which FIG. **5**A is an enlarged plan view and FIG. **5**B is an enlarged cross-sectional view along arrow B-B.

FIGS. **6**A and **6**B show the wippen holding member and the wippen shown in FIG. **2**, in which FIG. **6**A is an enlarged side view of the wippen and FIG. **6**B is an enlarged bottom view of the wippen.

FIGS. **7**A and **7**B show a process of attaching the wippen to the wippen holding member shown in FIG. **2**, in which FIG. **7**A is an enlarged side view showing a state in which the wippen holding member is positioned above the wippen in an upright state, and FIG. **7**B is an enlarged side view showing a state in which the wippen attached to the wippen holding member is positioned above the key after being rotated clockwise.

FIGS. **8**A and **8**B show respective portions of the hammer butt and the hammer, in which FIG. **8**A is an enlarged plan view and FIG. **8**B is an enlarged cross-sectional view along arrow C-C.

FIG. **9** is an enlarged side view showing the hammer butt and the hammer shown in FIG. **8**A.

FIGS. **10**A and **10**B show an enlarged side view of a process of attaching the hammer to the hammer butt shown in FIG. **2**, in which FIG. **10**A is an enlarged side view showing the hammer in an upright state in a position above the hammer butt and FIG. **10**B is an enlarged side view of the hammer being attached to the hammer butt and being rotated counterclockwise such that the hammer is positioned above the wippen.

FIGS. **11**A and **11**B show Modification Example 1 of an engaging part of a wippen and a wippen swing axis of a wippen holding member, in which FIG. **11**A is an enlarged side view of main components showing a state in which the wippen engaging part is engaged to the wippen swing axis and FIG. **11**B is an enlarged side view of main components showing a state in which the wippen engaging part is engaged to the wippen swing axis and is rotated clockwise.

FIGS. **12**A and **12**B show Modification Example 2 of a hammer engaging part of the hammer and a hammer swing axis of the hammer butt, in which FIG. **12**A is an enlarged side view of the main components showing a state in which the hammer engaging part is engaged to the hammer swing axis and FIG. **12**B is an enlarged side view of the main components in which the hammer engaging part is engaged to the hammer swing axis and rotated counterclockwise.

FIG. **13** is a plan view showing a Modification Example 3 of the keyboard instrument of one aspect of the present invention in which the wippen rail and the hammer rail are respectively divided into a plurality of wippen rails and hammer rails.

DETAILED DESCRIPTION OF EMBODIMENTS

An embodiment in which the electronic keyboard instrument of one aspect of the present invention is applied is described with reference to FIGS. **1** to **10**.

As shown in FIGS. **1** and **2**, this electronic keyboard instrument has a keyboard device **1**. This keyboard device **1** is assembled into an instrument case (not shown). The keyboard device **1** has a plurality of keys **2** that are aligned and has an action mechanism **3** that applies an action load to the respective keys **2** corresponding to a key depressing operation.

As shown in FIGS. **1** and **2**, the plurality of keys **2** include white keys **2***a* and black keys **2***b*, and 88 of these white keys **2***a* and black keys **2***b* are aligned. These plurality of keys **2** are aligned on a base plate **5** such that an approximately middle portion of the keys in the front and back direction (horizontal direction in FIG. **2**) is supported by balance pins **4***a* and **4***b* in a manner in which the keys can swing in the vertical direction.

In this case, as shown in FIG. **2**, cushion materials **6***a* and **6***b* are provided on a base plate **5** along the alignment direction of the keys **2** such that the respective bottom surfaces of respective front edge portions (right edge portion in FIG. **2**) of the plurality of keys **2** can come into contact with and move away from the cushion materials **6***a* and **6***b*. Furthermore, a cushion material **7** is provided on the base plate **5** along the alignment direction of the keys **2** such that each of the bottom surfaces of respective back edge portions of the keys **2** can come into contact with and move away from the cushion material **7**. In addition, guide pins **8***a* and **8***b* for preventing the plurality of keys **2** from horizontally oscillating in the alignment direction thereof are inserted and directed upward.

As shown in FIGS. **1** and **2**, the action mechanism **3** has a plurality of wippens **10** that respectively rotate in a vertical direction corresponding to the depression of the plurality of keys **2** and has a plurality of hammers **11** that apply an action load to the keys **2** when rotating in accordance with the vertical rotation of the wippens **10**.

As shown in FIG. **2**, this action mechanism **3** includes the wippen holding member **12** that is a plurality of wippen flanges **13** that hold the plurality of wippens **10** such that the wippens can rotate freely and that are integrally formed in the key **2** arrangement direction, and the hammer butt **14** that is a plurality of hammer flange **15** that hold the plurality of hammers **11** such that the hammers **11** can rotate freely and that are integrally formed in the key **2** arrangement direction.

In this case, as shown in FIGS. **2** and **3**, the wippen holding member **12** is attached on the wippen rail **17** along the key **2** arrangement direction. Furthermore, the hammer

butt **14** is attached on the hammer rail **18** that is disposed along the key **2** arrangement direction. These wippen rails **17** and the hammer rails **18** are supported by the plurality of supporting members **20** and are disposed above the plurality of keys **2**.

As shown in FIGS. **1** to **4**, the plurality of supporting members **20** are respectively attached in an upright state on the base plate **5** in a plurality of locations along the entire length of the plurality of keys **2** in the key **2** arrangement direction. In this case, 88 keys are arranged in total as the plurality of keys **2**, for example. Thus, the plurality of supporting members **20** are disposed on both edges of the keyboard device **1** in the key **2** arrangement direction and are provided on three locations between two adjacent keys **2** for every 20 keys **2**, for example. In other words, in this embodiment, the supporting members **20** are provided in five locations along the entire length of the plurality of keys **2** in the key **2** arrangement direction.

This supporting member **20** is formed of a hard synthetic resin such as an ABS resin, and as shown in FIGS. **3** and **4**, the supporting member **20** has an attaching part **20***a* that is attached on the base plate **5** and a bridging part **20***b* that is formed integrally on the attaching part **20***a*. As a result, the supporting member **20** is configured such that the attaching part **20***a* is attached on the base plate **5**, such that the bridge part **20***b* is positioned above the keys **2** between the respective back portions of the plurality of keys **2**.

In this case, as shown in FIGS. **3** and **4**, a back side rail supporting member **20***c* that supports the wippen rail **17** is provided on the lower back portion of the bridging portion **20***b*, or in other words, on the upper back portion of the attaching portion **20***a* (upper left side in FIG. **3**). In addition, a front side rail supporting member **20***d* that supports the hammer rail **18** is provided on the upper front side (upper right side in FIG. **3**) of the bridging part **20***b*. In addition, a stopper rail supporting part **20***e* is provided on the upper back side of the bridging part **20***b* and a substrate rail supporting part **20***f* is provided on the upper portion of the bridging part **20***b*.

As shown in FIGS. **2** and **3**, the wippen rail **17** is a metal such as aluminum, or the like, and the cross-section of the wippen rail **17** is in a rectangular cylindrical shape and has a length that extends across all of the keys **2** in the key **2** arrangement direction. The wippen rail **17** is configured such that prescribed locations thereof in the key **2** arrangement direction are attached to the respective back side rail supporting members **20***c* of the plurality of supporting members **20**.

As shown in FIGS. **2** and **3**, the plurality of wippen holding members **12** and a plurality of stopper supporting members **21** are attached along the key **2** arrangement direction. In this case, as shown in FIG. **3**, the plurality of stopper supporting members **21** are formed of a metal plate, and are attached on five locations on the wippen rail **17** that corresponds to the plurality of supporting members **10** such that the stopper supporting members **21** protrude above the plurality of wippen holding members **12**.

As shown in FIGS. **5**A and **5**B, the wippen holding members **12** are formed of a hard synthetic resin such as an ABS resin and the plurality of wippen flanges **13** are integrally formed along the key **2** arrangement direction on top of a main body plate **12***a* for approximately ten keys **2**, for example. This wippen flange **13** includes an axis supporting member **22** to which the wippen **10** is attached such that the wippen **10** can freely rotate and is suppressed from horizontally oscillating, and a restricting part that restricts the horizontal oscillation of the wippen **10** during packing and transport.

In this case, as shown in FIGS. **3** and **5**, the axis supporting member **22** has a pair of guiding walls **22***a* that is respectively formed on the back edge portion (left edge portion in FIG. **3**) of the main body plate **12***a* of the wippen holding member **12** for each key **2**, and has a wippen swing axis **24** provided between the pair of guiding walls **22***a*. The pair of guiding walls **22***a* form a guiding portion that guides the wippen engaging part **26** (explained later) of the wippen **10** such that the wippen engaging part **26** can swing while the guiding walls **22***a* sandwich the wippen engaging part **26** such that the wippen engaging part **26** can slide.

As shown in FIGS. **3** and **5**, the restricting parts **23** are a pair of restricting walls that are formed on the front portion (right side portion in FIG. **3**) of the main body plate **12***a* of the wippen holding member **12** so as to correspond with the respective wippens **10**. As shown in FIG. **5**A, the restricting part **23** guides the wippen **10** such that the wippen **10** can swing while sandwiching the lower back side portion of the wippen **10** and also restricts the horizontal oscillation of the wippen **10** during packing and transport.

As shown in FIGS. **2** and **6**, the wippen **10** is formed of a hard synthetic resin such as an ABS resin, and includes the wippen main body **25** that rotates vertically in response to the depression of keys **2** and then rotates the hammer **11** vertically. The wippen also includes the wippen engaging part **26** that is integrally formed with the wippen main body **25** and that is attached to the wippen swing axis **24** of the wippen flange **13**.

As shown in FIGS. **6**A and **6**B, the wippen main body **25** is formed in a waffle-like shape. In other words, the waffle shape is formed of the wippen main body **25** that has thin vertical plate portions **25***a* and a plurality of ribs **25***b* that are formed around the vertical plate portions **25***a* in a grid pattern.

As can be seen from FIGS. **6**A and **6**B, the wippen main body **25** is configured such that the weight of the wippen **10** can be adjusted by changing the shape of the vertical plate portions **25***a* and the density of the plurality of ribs **25***b* that are formed. In addition, the wippen main body **25** is formed such that even if the thickness of the vertical plate portion **25***a* is made thinner, the plurality of ribs **25***b* secure the strength of the structure and also prevent sink marks from occurring in the vertical plate portion **25***a* during molding.

As shown in FIGS. **6** and **7**, the entire wippen engaging part **26** is formed in a reversed C shape protrusion on the back edge portion of the wippen main body **25** through a connecting neck portion **26***a*. In other words, as shown in FIG. **5**A, the wippen engaging part **26** has a thickness in the key **2** arrangement direction that is approximately the same length as the gap between the pair of guiding walls **22***a* of the axis supporting member **22**, and the wippen engaging part **26** is configured such that the wippen engaging part **26** can slide between the pair of guiding walls **22***a* and can be inserted therein.

As shown in FIGS. **6** and **7**, the wippen engaging part **26** is formed with an engaging hole **26***b* in the center that engages the wippen swing axis **24** of the wippen flange **13** such that the wippen engaging part **26** can swing. This is done by providing an insertion opening **26***c* in the back portion of the surrounding area of the engaging hole **26***b* through which the wippen swing axis **24** can be inserted and removed, and by attaching the wippen engaging part **26** to

the wippen swing axis **24** through inserting the wippen swing axis **24** into the engaging hole **26***b* via the insertion opening **26***c*.

In this case, as shown in FIG. **5**B, cutouts **24***a* are formed on both front and back sides of the wippen swing axis **24** of the wippen flange **13** in a substantially vertical state such that the cutouts **24***a* are substantially perpendicular to each other. As a result, the wippen swing axis **24** is formed such that a length L**1** thereof in the front to back direction (horizontal direction in FIG. **5**B) is smaller than the outer diameter R**1** (L**1**<R**1**) of the wippen swing axis **24**. As shown in FIG. **6**A, the wippen engaging part **26** is formed such that the inner diameter R**2** of the engaging hole **26***b* has the same size as the outer diameter R**1** of the wippen swing axis **24** (R**2**≈R**1**).

As shown in FIGS. **6** and **7**, the insertion opening **26***c* of the wippen engaging part **26** is formed radially from the center of the engaging hole **26***b* to the periphery of the wippen engaging part **26**. As a result, the insertion opening **26***c* is wider towards the periphery of the wippen engaging part **26** and is narrower toward the inner side or the periphery of the engaging hole **26***b*. An opening width W**1** of the narrowest portion of this insertion opening **26***c*, or in other words, the portion located on the periphery of the engaging hole **26***b*, may have the same length as the length L**1** of the wippen swing axis **24** in the front to back direction, but it is preferable that the length of the opening width W**1** be slightly narrower (W**1**≤L**1**).

Thus, as shown in FIG. **7**A, when the wippen swing axis **24** is inserted into the engaging hole **26***b* through the insertion opening **26***c*, the wippen **10** is positioned above the wippen swing axis **24** in an upright state such that the insertion opening **26***c* faces the cutout **24***a* of the wippen swing axis **24**, and the insertion opening **26***c* is pressed into the cutout **24***a* of the wippen swing axis **24**, slightly widening the insertion opening **26**, and as a result, the wippen swing axis **24** is inserted in and engaged to the engaging hole **26***b* of the wippen engaging part **26**.

As shown in FIGS. **5**A and **6**B, the wippen engaging part **26** is configured such that a slit **26***d* is formed in the middle portion in the thickness direction of the wippen engaging part **26** along a direction perpendicular to the axis direction of the wippen swing axis **24**, or in other words, along the long side direction of the wippen **10**. As a result, the wippen engaging part **26** is configured to be elastically deformed in the thickness direction thereof, which is the axis direction of the wippen swing axis **24**. As a result, the wippen engaging part **26** is configured to elastically contact respective opposing faces of the pair of guiding walls **22***a* through the slit **26***d* when the wippen engaging part **26** is inserted between the pair of guiding walls **22***a*.

Meanwhile, as shown in FIGS. **6**A and **6**B, a thin engaging section **27** that is restricted by the restricting part **23** of the wippen holding member **12** is provided on the lower back side of the wippen main body **25** of the wippen **10**. This engaging section **27** is formed by cutting out both side faces in the lower back side of the wippen main body **25** with a thickness that is substantially the same length as the gap between the pair of restricting walls of the restricting parts **23**. As a result, the engaging section **27** is configured to be able to swingably guide the wippen **10** and restrict the horizontal oscillation of the wippen **10** during packing and transport by the wippen **10** being inserted between the pair of restricting walls of the restricting parts **23**.

As shown in FIGS. **2** and **7**, the wippen main body **25** of the wippen **10** is formed such that the lower portion thereof protrudes toward the upper surface of the key **2**. A first wippen felt **28** is provided on the bottom portion of the wippen main body **25**. The first wippen felt **28** is configured such that the capstan **29** provided on the upper back side of the key **2** abuts the first wippen felt **28** from the bottom side. As a result, the wippen **10** is configured to rotate counterclockwise with the wippen swing axis **24** as the center when the key **2** is depressed, and the wippen **10** is pushed upward by the capstan **29** of the key **2** that abuts the first wippen felt **28** from the bottom side.

Furthermore, as shown in FIGS. **2** and **7**B, the upper front portion of the wippen main body **25** of the wippen **10** is elevated compared to the upper back portion thereof, and as a result, the upper side portion of the wippen main body **25** is slanted such that the back portion is lower. A second wippen felt **30** is provided on the upper front portion of the wippen main body **25**.

As shown in FIGS. **2** and **7**B, the second wippen felt **30** is configured such that the hammer projection **31** (described later) of the hammer **11** is abutted from above. As a result, the wippen **10** is configured such that when the key **2** is depressed and the wippen **10** rotates counterclockwise with the wippen swing axis **24** in the center, the hammer projection **31** of the hammer **11** is pushed upward to rotate the hammer **11** clockwise.

Meanwhile, as shown in FIGS. **1** to **3**, the hammer rail **18** is formed of a metal such as a steel plate or aluminum, and has a length that extends across all of the keys **2** in the key **2** arrangement direction, and the cross-section thereof is formed in a rectangular cylindrical shape in a manner similar to the wippen rail **17**. The hammer rail **18** is configured such that prescribed locations thereof in the key **2** arrangement direction are attached to the respective front side rail supporting members **20***d* of the plurality of supporting members **20**. On this hammer rail **18**, a plurality of hammer butts **14** are attached along the arrangement direction of the keys **2**.

As shown in FIGS. **8**A and **8**B, the hammer butts **14** are formed of a hard synthetic resin such as an ABS resin and the hammer flanges **15** thereof are integrally formed along the key **2** arrangement direction for approximately ten keys **2** at the back edge portion of the main body plate **14***a* that is in a rail shape with an open upper side, for example. This hammer flange **15** has the axis supporting member **32** that the hammer **11** is attached to in a rotatable manner and that can prevent the horizontal oscillation of the hammer **11**.

In this case, as shown in FIGS. **3** and **8**, the axis supporting member **32** has a pair of guiding walls **32***a* that are formed for respective wippens **10** on the back edge portion (left edge portion in FIG. **3**) of the main body plate **14***a* of the hammer butt **14**, and a hammer swing axis **34** formed between the pair of guiding walls **32***a*. The pair of guiding walls **32***a* has a guiding portion that guides the hammer engaging part **37** of the hammer **11** in a swingable manner while sandwiching the hammer engaging part **37** (described later) from two sides such that the hammer engaging part **37** can slide.

As shown in FIGS. **8** and **9**, the hammer **11** is formed of a hard synthetic resin such as an ABS resin, and has the hammer portion **35** and the hammer shank **36** that are formed integrally. The hammer portion **35** has a vertical plate portion **35***a* that is in a light bulb shape, and has ribs **35***b* formed on the periphery and on both side faces thereof. The hammer shank **36** has a horizontal plate portion **36***a* in which the length in the front to back direction thereof is substantially the same length as the wippen **10**, and the ribs **36***b* are formed on the periphery and both side faces of the hammer shank **36**.

As shown in FIGS. **8** and **9**, the front edge portion (right edge portion in FIG. **9**) of the hammer shank **36** has the hammer engaging part **37** that is attached to the axis supporting member **32** of the hammer butt **14** in a rotatable manner. This hammer engaging part **37** is formed in a C shape similar to the wippen engaging part **26**, and is formed as a protrusion protruding towards the front from the front edge portion of the hammer shank **36** through the connecting neck portion **37***a*. In other words, the hammer engaging part **37** is formed with a thickness in the key **2** arrangement direction that is substantially the same in length with the gap between the pair of guiding walls **32***a* of the axis supporting member **32**, and the hammer engaging part **37** can be inserted into the gap between the guiding walls **32***a* such that the hammer engaging part **37** can slide.

As shown in FIGS. **8** to **10**, the hammer engaging part **37** has an engaging hole **37***b* in the center that engages the hammer swing axis **34** of the hammer flange **15**, and has an insertion opening **37***c* to which the hammer swing axis **34** can be inserted or removed in a portion of the periphery of the engaging hole **37***b*, or in other words, on the front portion of the periphery of the engaging part **37**, and the hammer engaging part **37** is attached to the hammer swing axis **34** in a swingable manner by inserting the hammer swing axis **34** into the engaging hole **37***b* through the insertion opening **37***c*.

In this case, as shown in FIGS. **8** to **10**, the hammer swing axis **34** of the hammer flange **15** has cutouts **34***a* in a substantially perpendicular state on both sides in the front to back direction so as to be substantially perpendicular to each other. As a result, the hammer swing axis **34** is formed such that a length L**2** thereof in the front to back direction (horizontal direction in FIG. **8**B) is smaller than the outer diameter R**3** (L**2**<R**3**) of the hammer swing axis **34**. As shown in FIG. **10**A, the hammer engaging part **37** is formed such that the inner diameter R**4** of the engaging hole **37***b* is the same size as the outer diameter R**3** of the hammer swing axis **34** (R**4**≈R**3**).

As shown in FIGS. **9** and **10**, the insertion opening **37***c* of the hammer engaging part **37** is formed radially from the center of the engaging hole **37***b* to the periphery of the hammer engaging part **37**. As a result, the insertion opening **37***c* is formed in a similar manner to the insertion opening **26***c* of the wippen engaging part **2**, i.e., the opening towards the periphery of the hammer engaging part **37** is wider and the opening towards the inside which is also the periphery of the engaging hole **37***b* is narrower. An opening width W**2** of the narrowest portion of this insertion opening **37***c*, or in other words, the portion located on the periphery of the engaging hole **37***b*, may have the same length as the length L**2** of the hammer swing axis **34** in the front to back direction, but it is preferable that the length of the opening width W**2** be slightly narrower (W**2**≤L**2**).

As a result, as shown in FIGS. **9** and **10**, the hammer engaging part **37** is configured such that when the hammer swing axis **34** is inserted into the engaging hole **37***b* through the insertion opening **37***c*, the hammer **11** is positioned above the hammer swing axis **34** in an upright state such that the insertion opening **37***c* faces the cutout **34***a* of the hammer swing axis **34**, and the insertion opening **37***c* is pressed into the cutout **34***a* of the hammer swing axis **34**, slightly widening the insertion opening **37***c*, and as a result, the hammer swing axis **34** is inserted in and engaged to the engaging hole **37***b* of the hammer engaging part **37**.

As shown in FIG. **8**A, the hammer engaging part **37** is configured such that a slit **37***d* is formed in the middle portion in the thickness direction of the hammer engaging part **37** along a direction perpendicular to the axis direction of the hammer swing axis **34**, or in other words, along the long side direction of the hammer **11**. As a result, the hammer engaging part **37** is configured to be elastically deformed in the thickness direction thereof which is the axis direction of the hammer swing axis **34**. As a result, the hammer engaging part **37** is configured to elastically contact with respective opposing faces of the pair of guiding walls **32***a* through the slit **37***d* when the hammer engaging part **37** is inserted between a pair of guiding walls **32***a*.

As shown in FIGS. **9** and **10**, on the lower front edge portion of the hammer shank **36**, a hammer projection **31** that abuts the second wippen felt **30** provided on the upper front edge portion of the wippen main body part **25** of the wippen **10** from above. As a result, the hammer **11** is configured to rotate clockwise about the hammer swing axis **34** of the hammer flange **15** when the hammer projection **31** is pushed upward in response to the wippen **10** rotating counterclockwise.

As shown in FIGS. **2** and **10**B, the hammer shank **36** is configured such that the initial position, which is the lower limit position, is restricted by the hammer rest **38** abutting the lower back edge portion of the hammer shank **36**. In other words, the hammer rest **38** is attached to a hammer rest rail **39** supported by the plurality of stopper supporting members **21** provided on the wippen rail **17**. In this case, as shown in FIGS. **10**A and **10**B, the plurality of stopper supporting members **21** are formed such that the respective upper portions thereof are slanted downward towards the back portion.

As shown in FIGS. **1** and **10**, the hammer rest rail **39** is formed of a metal such as a steel plate or aluminum, for example, and is formed in a rail shape with the bottom side thereof being open, and has a length that extends across all of the keys **2** in the key **2** arrangement direction. This hammer rest rail **39** is attached on top of the respective plurality of stopper supporting members **21** such that the hammer rest rail **39** is inclined downward towards the back portion. As a result, the hammer rest **38** is attached on the hammer rest rail **39** such that the hammer rest **38** is inclined downward towards the back portion. Therefore, the initial position of the hammer **10** that is inclined downward toward the back is restricted by the hammer shank **36** thereof abutting the hammer rest **38** from above.

In addition, as shown in FIGS. **2** and **10**B, the hammer shank **36** is configured such that the upper limit position thereof is restricted by the upper back edge thereof abutting the upper limit stopper **40**. In other words, this upper limit stopper **40** is attached to the bottom surface of the upper limit stopper rail **41** that is attached to the respective stopper rail supporting part **20***e* of the plurality of supporting members **20**.

In this case, as shown in FIGS. **2** and **10**B, the upper limit stopper rail **41** is formed of a steel plate, or a metal such as aluminum, and is a plate having a substantially L shaped cross-section. In addition, the upper limit stopper rail **41** has a length that extends across all of the keys **2** in the key **2** arrangement direction. The vertical portion of the upper limit stopper rail **41** is attached to the respective stopper rail supporting parts **20***e* by a vis **41***a* while the horizontal portion of the upper limit stopper rail **41** protrudes towards the back from the respective stopper rail supporting part **20***e* of the plurality of support members **20**.

As shown in FIGS. **2** and **10**B, the upper limit stopper **40** is provided on the bottom surface of the horizontal portion of the upper limit stopper rail **41**. As a result, the upper limit position of the hammer **10** is restricted by the upper back

edge portion of the hammer shank **36** abutting the upper limit stopper **40** from the bottom when the hammer shank **36** rotates clockwise with the hammer swing axis **34** of the hammer flange **15** as the center.

As shown in FIGS. **2** and **10**B, a switch pressing part **42** is formed on the upper front edge portion of the hammer shank **36**. A switch substrate **43** is disposed in a position above the switch pressing part **42** of the hammer shank **36** through a pair of substrate support rails **44**. The pair of substrate support rails **44** are formed such that a cross-section thereof has an L shape, and each of the substrate support rails **44** has a length that extends across all of the keys **2** in the key **2** arrangement direction.

As shown in FIGS. **2** and **10**B, the pair of substrate support rails **44** is formed of a steel plate or a metal such as aluminum, and the horizontal portions thereof are respectively attached to the substrate rail supporting part **20***f* of the supporting member **20** with a prescribed gap between the two substrate support rails **44**. As shown in FIG. **1**, the switch substrate **43** is divided into parts. In other words, in this embodiment, the switch substrate **43** is divided into four parts each having a length corresponding to approximately 20 keys **2** and each being attached to the pair of substrate support rails **44**, for example.

As shown in FIGS. **1**, **2**, and **10**B, a rubber switch **45** is provided on the bottom surface of each of the switch substrates **43**. This rubber switch **45** has a rubber sheet that extends along the key **2** arrangement direction and a bulged portion **45***a* with a reversed dome shape formed on the rubber sheet for each of the plurality of hammer shanks **36**. A plurality of moving contacts **45***b* are formed along the front to back direction of the hammer shank **36** in the bulged portion **45***a*. The moving contacts can contact with or detach from a plurality of fixed contacts (not shown) that are provided on the bottom surface of the switch substrate **43**.

As shown in FIG. **2**, the rubber switch **45** is configured to send a switch signal corresponding to the strength in which the key **2** is depressed. Here, the depressing of the key **2** causes the plurality of moving contacts **45***b* to contact the plurality of fixed contacts one after another after the hammer **11** rotates clockwise with the hammer swing axis **34** of the hammer flange **15** as the center. Then, the hammer shank **36** pushes the switch pressing part **42** from the bottom side, and elastically deforms the reverse dome shaped bulged portion **45***a*. A sound source **43***a* provided on the switch substrate **43** generates a sound signal in response to the switch signal and the speaker (not shown) generates a sound based on the sound signal.

Next, the assembly of the keyboard device **1** of this type of electronic keyboard instrument is described.

First, the plurality of keys **2** and the plurality of supporting members **20** are provided on the base plate **5**. In this case, as shown in FIGS. **1** and **2**, 88 keys **2** are attached and arranged in a line on the base plate **5** with the balance pins **4***a* and **4***b* such that the keys **2** can swing in the vertical direction. In addition, the supporting members **20** are placed on both end portions of the base plate **5** in the key **2** arrangement direction and are provided in three locations between the respective keys **2** for every twenty keys **2**.

As shown in FIG. **3**, next, the wippen rail **17** is attached across the entire length of the plurality of keys **2** in the key **2** arrangement direction on the respective back side rail supporting members **20***c* of the plurality of supporting members **20**, and the plurality of wippen holding members **12** and the plurality of stopper supporting members **21** are attached on the wippen rail **17** along the key **2** arrangement direction.

In this case, the plurality of stopper supporting members **21** that are protruding upward are attached above the wippen rail **17** at five locations that respectively correspond to the plurality of supporting members **20**. In a similar manner, the hammer rail **18** is attached on the respective front side rail supporting member **20***d* and is disposed along the entire length of the plurality of keys **2** in the key **2** arrangement direction, and a plurality of hammer holding members **14** are attached on the hammer rail **18** along the key **2** arrangement direction.

Then, the plurality of wippens **10** are respectively attached on the wippen flanges **13** of the plurality of wippen holding members **12** one after another. In this case, as shown in FIG. **7**A, the wippen **10** is positioned above the wippen flange **13** in an upright state such that the insertion opening **26***c* of the wippen engaging part **26** faces the wippen swing axis **24**, and the wippen swing axis **24** engages the engaging hole **26***b* by being pressed into the insertion opening **26***c*.

The insertion opening **26***c* can engage the wippen swing axis **24** with ease because the insertion opening **26***c* of the wippen engaging part **26** is wider toward the outside and narrower toward the inside. Furthermore, when the wippen swing axis **24** engages the insertion opening **26***c*, the cutout **24***a* of the wippen swing axis **24** slightly widens the insertion opening **26***c* and thereby allowing the wippen swing axis **24** to swingably engage the engaging hole **26***b* through the insertion opening **26***c*. Then, the wippen **10** is rotated clockwise with the wippen swing axis **24** as the center.

During this step, when the wippen engaging part **26** is inserted between the pair of guiding walls **22***a* of the axis supporting member **22**, the wippen engaging part **26** is in elastic contact with and sandwiched by the respective opposing faces of the pair of guiding walls **22***a* through the slit **26***d* of the wippen engaging part **26**. As a result, the wippen **10** does not horizontally oscillate in the key **2** arrangement direction. Furthermore, at this time, the first wippen felt **28** on the bottom portion of the wippen **10** abuts the capstan **29** of the key **2** from above, thereby restricting the initial position of the wippen **10**.

In this case, the engaging section **27** provided on the lower back side portion of the wippen **10** is inserted between the pair of restricting walls that are the restricting parts **23** of the wippen flange **15**. In addition, the engaging section **27** rotatably guides the wippen **10** and restricts the wippen **10** from horizontally oscillating in the key **2** arrangement direction during packing and transport. In this situation, the wippen engaging part **26** does not indeliberately break away from the wippen swing axis **24** through the insertion opening **26***c*, because the insertion opening **26***c* of the wippen engaging part **26** corresponds to the cutout **24***a* of the wippen swing axis **24**.

In other words, first, the plurality of wippens **10** are positioned in an upright state respectively facing the wippen flanges **13** of the wippen holding members **12**, and then the wippen engaging parts **26** of the wippen **10** are respectively engaged to the wippen swing axes **24** of the wippen flange **13** one after another so as to respectively attach the plurality of wippens **10** to the wippen flange **13** one after another. This attaching process is performed in a similar manner for the respective wippen flanges **13** of the plurality of wippen holding members **12**. As a result, all of the wippens **10** that respectively correspond to all of the keys **2** are attached.

Next, the hammer rest rail **39** is attached to the upper portion of the plurality of stopper supporting members **21**, and then the hammer rest **38** is attached on top of the hammer rest rail **39**. After that, the plurality of hammers **11** are respectively attached to the hammer flanges **15** of the

plurality of hammer butts **14**. In this case, as shown in FIG. **10**A, the hammer **11** is positioned above the hammer flange **15** in an upright state such that the insertion opening **37***c* of the hammer engaging part **37** faces the hammer swing axis **34** of the hammer flange **15**, and the hammer swing axis **2** **34** engages the engaging hole **37***b* by being pressed into the insertion opening **37***c*.

The insertion opening **37***c* is wider towards the periphery of the hammer engaging part **37** and is narrower towards the inside, and thus the insertion opening **37***c* can engage the hammer swing axis **34** with ease. When the hammer swing axis **34** is inserted into the insertion opening **37***c*, the hammer swing axis **34** engages the engaging hole **37***b* through the insertion opening **37***c* as the insertion opening **37***c* is slightly widened by the cutout **34***a* of the hammer swing axis **34**.

When the hammer engaging part **37** is inserted between the pair of guiding walls **32***a* of the axis supporting member **32**, the hammer engaging part **37** is in elastic contact with and sandwiched by the respective opposing faces of the pair of guiding walls **22***a* through the slit **37***d* of the hammer engaging part **37**. As a result, the hammer **11** swings in the vertical direction without horizontally oscillating in the key **2** arrangement direction.

Next, the hammer **11** is rotated counterclockwise with the hammer swing axis **34** as the center. Then, the hammer projection **31** of the hammer **11** abuts the second wippen felt **30** of the wippen **10** from above and the lower back portion of the hammer shank **36** abuts the hammer rest **38** from above. As a result, the hammer **11** is restricted in an initial position with a downward inclination from front to back.

In this manner, first, the plurality of hammers **11** are each set in an upright position corresponding to each of the hammer flanges **15**. Then, each of the hammer engaging parts **37** of the hammer **11** is engaged to each of the hammer swing axes **34** of the hammer flange **15** one after another to serially engage each of the plurality of hammers **11** to each of the hammer flanges **15** of the hammer butt **14**. This attaching process is performed in a similar manner for the respective hammer flanges **15** of the plurality of hammer butts **14**. As a result, all of the hammers **11** that respectively correspond to all of the keys **2** are attached.

Then, the upper limit stopper rail **41** is attached to the respective stopper rail supporting parts **20***e* of the plurality of supporting members **20**. Furthermore, a pair of substrate support rails **44** is attached with a prescribed gap therebetween on the respective substrate rail supporting parts **20***f* of the plurality of supporting members **20**, and then the plurality of switch substrates **43** is attached on the pair of substrate support rails **44** along the key **2** arrangement direction.

In this case, the rubber switch **45** is attached to the bottom surface of the switch substrate **43** in advance. In addition, when the switch substrate **43** is attached on the pair of substrate support rails **44**, each of the bulged portions **45***a* of the rubber switch **45** is made to correspond to each of the switch pressing parts **42** of the plurality of hammer shanks **36**.

Next, the effects of the keyboard device **1** of this type of electronic keyboard instrument are described.

This keyboard device **1** is played by depressing the keys **2**. At this time, if the key **2** is depressed, the key **2** swings clockwise with the balance pins **4***a* and **4***b* as the center, and the capstan **29** of the key **2** pushes the wippen **10** upward. As a result, the wippen **10** swings counterclockwise with the wippen swing axis **24** of the wippen flange **13** as the center.

At this point, the wippen swing axis **24** of the wippen flange **13** is engaged to the engaging hole **26***a* of the wippen engaging part **26**, and therefore, the wippen **10** does not shift in the front to back direction of the keys **2** and the wippen **10** rotates smoothly with the wippen swing axis **24** as the center. In addition, at this point, the wippen engaging part **26** of the wippen **10** is guided by being sandwiched between the pair of guiding walls **22***a* of the wippen flange **13** in a rotatable manner, and thus the wippen **10** does not horizontally oscillate and swings smoothly in the vertical direction.

In this manner, when the wippen rotates counterclockwise by being pushed upward by the capstan **29** of the key **2**, the second felt **30** of the wippen **10** pushes the hammer projection **31** of the hammer **11** upward. As a result, the hammer **11** swings clockwise with the hammer swing axis **34** of the hammer flange **15** as the center and applies an action load to the key **2**.

At this point, in a similar manner to the wippen **10**, the hammer swing axis **34** of the hammer flange **15** is engaged to the engaging hole **37***a* of the hammer engaging part **37** of the hammer **11**, and thus, the hammer **11** smoothly swings with the hammer swing axis **34** as the center without shifting in the front to back direction of the keys **2**. In addition, at this point, the hammer engaging part **37** of the hammer **11** is guided by being sandwiched between the pair of guiding walls **32***a* of the hammer flange **15** in a swingable manner. Therefore, the hammer engaging part **37** of the hammer **11** is guided through being sandwiched between the pair of guiding walls **32***a* of the hammer flange **15** in a swingable manner, and thus, the hammer **11** does not horizontally oscillate and swings smoothly in the vertical direction.

When the hammer **11** swings clockwise with the hammer swing axis **34** as the center, an action load is applied to the key **2** by the moment of inertia of the hammer **11**. In other words, the hammer shank **36** is formed having substantially the same length as the length of the wippen **10** in the front to back direction of the key **2**, and the hammer portion **35** is formed on the back edge portion of the hammer shank **36**. At this point, the engaging part **37** of the front edge portion of the hammer shank **36** is swingably attached to the hammer swing axis **34**.

When the hammer **11** swings clockwise with the hammer swing axis **34** as the center, an action load is applied to the key **2** by the moment of inertia of the hammer **11**. As a result, a touch of the keys very similar that of an acoustic piano can be obtained.

In this manner, when the hammer **11** swings clockwise with the hammer swing axis **34** as the center, then the switch pressing part **42** of the hammer shank **36** pushes the reverse dome shaped bulged portion **45***a* of the rubber switch **45** provided on the switch substrate **43** from the bottom side. Thus, the reverse dome shaped bulged portion **45***a* elastically deforms and the plurality of moving contacts **45***b* in the bulged portion **45***a* contacts the plurality of fixed contacts one after another to output a switch signal depending on the strength of the depression of the key **2**. As a result, a sound is generated by the speaker (not shown).

Then, when the hammer **11** swings further clockwise with the hammer swing axis **34** as the center, the upper back edge portion of the hammer shank **36** abuts the upper limit stopper **40** from the bottom side, thereby restricting the swing of the hammer **11**. Next, when the key **2** starts being released, the wippen **10** swings clockwise and returns to the initial position and the hammer **11** rotates counterclockwise and returns to the initial position.

In this manner, an electronic keyboard instrument that is easy to assemble, has high productivity, and has low cost can

be produced by the action mechanism **3** of this electronic keyboard instrument having: the plurality of keys **2** aligned, the plurality of wippens **10** that respectively swing in the vertical direction according to the depressing of the plurality of the keys **2**, the plurality of hammers **11** that applies an action load to the respective plurality of keys **2** by respectively swinging in the vertical direction according to the swinging action of the plurality of wippens **10**, and the wippen holding member **12** having the plurality of wippen flanges **13** that are integrally formed along the key **2** arrangement direction and that swingably holds the plurality of wippens **10**.

In other words, with the action mechanism **3** of this electronic keyboard instrument, the respective plurality of wippen flanges **13** that swingably holds the respective plurality of wippens **10** do not need to be manufactured and assembled individually before attaching the plurality of wippens **10** to the wippen holding member **12**, and the plurality of wippen flanges **13** can be disposed at once by just installing the wippen holding member **12**. As a result, because the assembly process is easier, the productivity improves and the cost is reduced.

In this case, each of the plurality of wippen flanges **13** of the wippen holding members **12** has the wippen swing axis **24** and each of the wippens **10** has the wippen engaging part **26** that can be swingably attached to the wippen swing axis **24** from a direction perpendicular to the axis direction. Therefore, the assembly productivity is excellent because the wippen **10** can be attached to the wippen flange **13** with ease by simply inserting the wippen engaging part **26** of the wippen **10** to the wippen swing axis **24** of the wippen flange **13** from the direction perpendicular to the axis direction.

In other words, the pair of cutouts **24***a* are provided on both sides of the wippen swing axis **24** of the wippen flange **13** in a substantially perpendicular state parallel to each other, the engaging hole **26***b* is formed in the center of the wippen engaging part **26** of the wippen **10**, and the insertion opening **26***c* is formed in the periphery of the engaging hole **26***b*. As a result, the wippen **10** can be attached to the wippen flange **13** with ease by the wippen swing axis **24** engaging the engaging hole **26***b* of the wippen engaging part **26** through the insertion opening **26***c* of the wippen engaging part **26** from above in the perpendicular direction along the pair of cutouts **24***a* formed on both side portions of the wippen swing axis **24**.

In this case, the wippen swing axis **24** has a length L**1** in the front to back direction that is smaller than the outer diameter R**1** of the wippen swing axis **24**. The wippen engaging part **26** is formed such that the inner diameter R**2** of the engaging hole **26***b* has the same size as the outer diameter R**1** of the wippen swing axis **24**, and the opening width W**1** of the narrowest portion of this insertion opening **26***c* is slightly narrower than the length L**1** of the wippen swing axis **24** in the front to back direction. As a result, when the wippen swing axis **24** is inserted into the engaging hole **26***b* through the insertion opening **26***c* of the wippen engaging part **26**, the wippen swing axis **24** engages the engaging hole **26***b* by being pressed into the insertion opening **26***c* and the cutout **24***a* of the wippen swing axis **24** slightly widening the insertion opening **26***c*.

Thus, even if the wippen holding members **12** having the plurality of wippen flanges **13** formed along the key **2** arrangement direction are installed before the plurality of wippens **10** are attached to the wippen holding members **12**, the wippens **10** can be respectively attached to the plurality of wippen flanges **13** one after another with ease, thereby making the assembly process easier and improving the productivity. In this case, the insertion opening **26***c* can engage the wippen swing axis **24** with ease because the insertion opening **26***c* of the wippen engaging part **26** is wider toward the outside and narrower toward the inside, thereby making the assembly process easier and improving the productivity.

In addition, through providing the pair of guiding walls **22***a* that prevent horizontal oscillation of the wippen **10** on the wippen flange **13**, the wippen engaging part **26** of the wippen **10** is swingably attached to the wippen swing axis **24** of the wippen flange **13**, thereby slidably sandwiching the wippen engaging part **26** with the pair of guiding walls **22***a*. In this case, the slit **26***d* is formed along the long side direction of the wippen **10** in the wippen engaging part **26**, and when the wippen engaging part **26** is inserted between the pair of guiding walls **22***a*, the wippen engaging part **26** can be can be elastically in contact with the pair of guiding walls **22***a* in a slidable manner through the slit **26***d*.

As a result, with this action mechanism **3**, when the wippen **10** swings according to key depression, the pair of guiding walls **22***a* of the wippen flange **13** prevents the wippen **10** from horizontally oscillating in the key **2** arrangement direction, and therefore the wippen **10** can be smoothly swung in an excellent manner and the positional accuracy and the operating accuracy of the wippen **10** can be improved.

Furthermore, the restricting part **23** that restricts the horizontal position of the wippen **10** is provided on the wippen flange **13** and the restricting part **23** is a pair of restricting walls that are formed on the main body plate **12***a* of the wippen holding member **12**, and is configured to restrict the horizontal position of the wippen **10** while sandwiching the engaging section **27** in which both side faces thereof on the lower back side portion of the engaging section **27** of the wippen **10** is cut out, and the wippen **10** can be swingably guided and the position of the wippen **10** can be excellently restricted without the wippen **10** horizontally oscillating during packaging and transport.

In addition, an electronic keyboard instrument that is easy to assemble, has high productivity, and has low cost can be produced by the action mechanism **3** of this electronic keyboard instrument having: the plurality of keys **2** aligned, the plurality of wippens **10** that respectively swing in the vertical direction according to the depressing of the plurality of the keys **2**, the plurality of hammers **11** that applies an action load to the respective plurality of keys **2** by respectively swinging in the vertical direction according to the swinging action of the plurality of wippens **10**, and the hammer flange **14** having the plurality of hammer butts **15** that are integrally formed along the key **2** arrangement direction and that swingably holds the plurality of hammers **11**.

In other words, with the action mechanism **3** of this electronic keyboard instrument, the respective plurality of hammer flanges **15** that swingably holds the respective plurality of hammers **11** do not need to be manufactured and assembled individually before attaching the plurality of hammers **11** to the hammer butt **14**, and the plurality of hammer flanges **15** can be disposed at once by just installing the hammer butt **14**. As a result, because the assembly process is easier, the productivity improves and the cost is reduced.

In this case, each of the plurality of hammer flanges **15** of the hammer butt **14** has the hammer swing axis **34** and each of the hammers **11** has the hammer engaging part **37** that can be swingably attached to the hammer swing axis **34** from a direction perpendicular to the axis direction. Therefore, the

assembly productivity is excellent because the hammer **11** can be attached to the hammer flange **15** with ease by simply inserting the hammer engaging part **37** of the hammer **11** to the hammer swing axis **34** of the hammer flange **15** from the direction perpendicular to the axis direction.

In other words, the pair of cutouts **34***a* are provided on both sides of the hammer swing axis **34** of the hammer flange **15** in a substantially perpendicular state parallel to each other, the engaging hole **37***b* is formed in the center of the hammer engaging part **37** of the hammer **11**, and the insertion opening **37***c* is formed in the periphery of the engaging hole **37***b*. As a result, the hammer **11** can be attached to the hammer flange **15** with ease by the hammer swing axis **34** engaging the engaging hole **37***b* of the hammer engaging part **37** through the insertion opening **37***c* of the hammer engaging part **37** from above in the vertical direction along the pair of cutouts **34***a* formed on both side portions of the hammer swing axis **34**.

In this case, the hammer swing axis **34** has the length L**2** in the front to back direction that is smaller than the outer diameter R**3** of the hammer swing axis **34**, the hammer engaging part **37** is formed such that the inner diameter R**4** of the engaging hole **37***b* has the same size as the outer diameter R**3** of the hammer swing axis **34**, and the opening width W**2** of the narrowest portion of this insertion opening **37***c* is slightly narrower than the length L**2** of the hammer swing axis **34** in the front to back direction. As a result, when the hammer swing axis **34** is inserted into the engaging hole **37***b* through the insertion opening **37***c* of the hammer engaging part **37**, the hammer swing axis **34** engages the engaging hole **37***b* by being pressed into the insertion opening **37***c* and the cutout **34***a* of the hammer swing axis **34** slightly widening the insertion opening **37***c*.

Thus, even if the hammer butts **14** having the plurality of hammer flanges **15** formed along the key **2** arrangement direction are installed before the plurality of hammers **11** are attached to the hammer butts **14**, the hammers **11** can be respectively attached to the plurality of hammer flanges **15** one after another with ease, thereby making the assembly process easier and improving the productivity. In this case, the insertion opening **37***c* is wider towards the periphery of the hammer engaging part **37** and is narrower towards the inside, and thus the insertion opening **37***c* can engage the hammer swing axis **34** with ease, and thereby making the assembly process easier and improving the productivity.

In addition, because the hammer flange **15** has the pair of guiding walls **32***a* that prevents the hammer **11** from horizontally oscillating, if the hammer engaging part **37** of the hammer **11** is swingably attached to the hammer swing axis **34** of the hammer flange **15**, the hammer engaging part **37** can be sandwiched by the pair of guiding walls **32***a* such that the hammer engaging part **37** can slide. In this case, because the slit **37***d* is formed along the long side direction of the hammer **11**, when the hammer engaging part **37** is inserted between the pair of guiding walls **32***a*, the hammer engaging part **37** can be elastically in contact with the pair of guiding walls **32***a* through the slit **37***d* such that the hammer engaging part **37** can slide.

As a result, with this action mechanism **3**, when the hammer **11** swings according to key depression, the pair of guiding walls **32***a* of the hammer flange **15** prevents the hammer **11** from horizontally oscillating in the key **2** arrangement direction, and therefore the hammer **11** can be smoothly swung in an excellent manner and the positional accuracy and the operating accuracy of the hammer **11** can be improved.

This action mechanism **3** includes the wippen rail **17** that is disposed along the key **2** arrangement direction and that has the wippen holding member **12**, and the hammer rail **18** that is disposed along the key **2** arrangement direction and that has the hammer butt **14**. Therefore, the wippen holding member **12** that is the plurality of wippen flanges **13** that are integrally formed in the key **2** arrangement direction can be attached on the wippen rail **17** one after another, and the hammer butt **14** that is the plurality of hammer flanges **15** that are integrally formed in the key **2** arrangement direction can be attached to the hammer rail **18** one after another, thereby simplifying the assembly process.

Furthermore, this action mechanism **3** of the electronic keyboard instrument includes the plurality of supporting members **20** that support the wippen rail **17** and the hammer rail **18**, and the plurality of supporting members **20** allow the wippen rail **17** and the hammer rail **18** to stably and reliably run the entire length of the plurality of keys **2** in the key **2** arrangement direction in an excellent manner, and thus the plurality of wippens **10** and the plurality of hammers **11** can be reliably attached in an excellent manner.

In the embodiment mentioned above, the cutouts **24***a* are formed on both sides of the wippen swing axis **24** provided on each of the wippen flanges **13** of the wippen holding member **12**, and the engaging hole **26***b* is formed in the center of the wippen engaging part **26** of the wippen **10**, and the insertion opening **26***c* is formed in a portion of the periphery of the wippen engaging part **26**, and the insertion openings **26***c* is slightly widened by the cutout **24***a* of the wippen swing axis **24** by being pressed in such that the wippen swing axis **24** is engaged to the engaging hole **26***b*, but the configuration is not limited to this, and may include a configuration for Modification Example 1 that is shown in FIGS. **11**A and **11**B, for example.

In Modification Example 1, the wippen swing axis **50** that is provided on each of the plurality of wippen flanges **13** of the wippen holding member **12** is formed in a cylindrical shape having a circular cross-section, the engaging hole **51***b* is formed in the center of the wippen engaging part **51** of the wippen **10**, the insertion opening **51***c* is formed in a portion of the periphery of the wippen engaging part **51**, and the wippen engaging part **51** is configured to elastically deform in the radial direction thereof.

In this case, the wippen engaging part **51** is configured to elastically deform in the radial direction by having an arc-shaped slit **51***d* along the periphery of the engaging hole **51***b*. As a result, even if the width W**3** of the narrowest portion of the insertion opening **51***c* is formed smaller than the outer diameter R**5** of the wippen swing axis **50**, the wippen engaging part **51** is configured to elastically deform in the radial direction of the engaging hole **51***b* when the wippen swing axis **50** is being inserted.

As shown in FIGS. **11**A and **11**B, in Modification Example 1, when the wippen swing axis **50** is inserted into the engaging hole **51***b* through the insertion opening **51***c* of the wippen engaging part **51**, the wippen **10** can be inserted into the insertion opening **51***c* of the wippen engaging part **51** from any direction perpendicular to the axis direction of the wippen swing axis **50**.

Furthermore, in the first Modification Example 1, when the wippen swing axis **50** is inserted into the insertion opening **51***c* of the wippen engaging part **51**, because the wippen engaging part **51** can be elastically deformed in an excellent manner by the insertion opening **51***c* thereof being widened in the radial direction, the wippen swing axis **50** can be reliably inserted into the engaging hole **51***b* in an excellent manner, and the wippen engaging part **51** deforms

back to the original shape and can elastically engage the wippen holding axis **50**. Therefore, the wippen **10** can be swingably attached to the wippen swing axis **50** in an excellent manner with the wippen swing axis **50** as the center.

In addition, in the embodiment mentioned above, the cutouts **34***a* are formed on both sides of the hammer swing axis **34** provided on each of the hammer flanges **15** of the hammer butt **14**, and the engaging hole **37***b* is formed in the center of the hammer engaging part **37** of the hammer **11**, and the insertion opening **37***c* is formed in a portion of the periphery of the hammer engaging part **37**, and the insertion openings **37***c* is slightly widened by the cutout **34***a* of the wippen swing axis **34** by being pressed in such that the wippen swing axis **34** is engaged to the engaging hole **37***b*, but the configuration is not limited to this, and may include a configuration for the Modification Example 2 that is shown in FIGS. **12**A and **12**B, for example.

In the Modification Example 2, the hammer swing axis **55** that is provided on each of the plurality of hammer flanges **15** of the hammer butt **14** is formed in a cylindrical shape having a circular cross-section, the engaging hole **56***b* is formed in the center of the hammer engaging part **56** of the hammer **11**, the insertion opening **56***c* is formed in a portion of the periphery of the hammer engaging part **56**, and the hammer engaging part **56** is configured to elastically deform in the radial direction thereof.

In this case, the hammer engaging part **56** is configured to elastically deform in the radial direction by having an arc-shaped slit **56***d* along the periphery of the engaging hole **56***b*. As a result, even if the width W**4** of the narrowest portion of the insertion opening **56***c* is formed smaller than the outer diameter R**6** of the hammer swing axis **55**, the hammer engaging part **56** is configured to elastically deform in the radial direction of the engaging hole **56***b* when the hammer swing axis **55** is being inserted.

As shown in FIGS. **12**A and **12**B, in Modification Example 2, when the hammer swing axis **55** is inserted into the engaging hole **56***b* through the insertion opening **56***c* of the hammer engaging part **56**, the hammer **11** can be inserted into the insertion opening **56***c* of the hammer engaging part **56** from any direction perpendicular to the axis direction of the hammer swing axis **55**.

Furthermore, in Modification Example 2, when the hammer swing axis **55** is inserted into the insertion opening **56***c* of the hammer engaging part **56**, because the hammer engaging part **56** can be elastically deformed in an excellent manner by the insertion opening **56***c* thereof being widened in the radial direction, the hammer swing axis **55** can be reliably inserted into the engaging hole **56***b* in an excellent manner, and the hammer engaging part **56** deforms back to the original shape and can elastically engage the hammer holding axis **55**. Therefore, the hammer **11** can be swingably attached to the hammer swing axis **55** in an excellent manner with the hammer swing axis **50** as the center.

Furthermore, in the embodiment mentioned above, a case in which the wippen rail **17** and the hammer rail **18** are formed across the entire length of the plurality of keys **2** in the key **2** arrangement direction has been described, but the present invention is not limited to this and may have a configuration such as that of Modification Example 3 shown in FIG. **13** in which the wippen rail **60** and the hammer rail **61** are respectively divided into several parts that are provided along the entire length of the plurality of keys **2** in the key **2** arrangement direction.

In this case, the wippen rail **60** and the hammer mil **61** may be divided into four, three, or two parts (each having half the length of the action mechanism **3** in the key **2** arrangement direction) in positions corresponding to respective groups of the supporting members **20**. Furthermore, in a similar manner, the hammer rest rail **39** and the upper limit stopper rail **41** may both be divided into four, three, or two parts (each having half the length of the action mechanism **3** in the key **2** arrangement direction) in positions corresponding to respective groups of the supporting members **20**.

Also, in the embodiment mentioned above, a case in which the plurality of wippen flanges **13** are integrally formed with the wippen holding members **12** such that each of the plurality of wippen flanges **13** is provided for approximately ten of the keys **2** and the plurality of hammer flanges **15** are integrally formed with the hammer holding members **14** such that each of the plurality of wippen flanges **13** is provided for approximately ten of the keys **2**, but the present invention is not limited to this, and each of the plurality of wippen flanges **13** and each of the plurality of hammer flanges **15** may be integrally formed for any number of the keys **2** such as twenty or five.

In addition, the wippen is not limited to those that swing, but may be configured to shift (move) when the key is depressed to transfer the force of the depression.

An embodiment of one aspect of the present invention was described above, but the present invention is not limited thereto, and encompasses the present invention stated in the claims and their equivalents. It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover modifications and variations that come within the scope of the appended claims and their equivalents. In particular, it is explicitly contemplated that any part or whole of any two or more of the embodiments and their modifications described above can be combined and regarded within the scope of the present invention.

What is claimed is:

1. A keyboard device, comprising:

a plurality of keys; and

a plurality of key action mechanisms respectively provided for the plurality of keys,

wherein each of said key action mechanisms includes:

a first shaft;

a pressing force transmit member that couples with the first shaft, and receives a pressing force from the corresponding key when the key is depressed so as to swing around the first shaft in response to a depression of the corresponding key;

a second shaft; and

a hammer that couples with the second shaft,

wherein the pressing force transmit member interfaces the hammer so that the hammer applies a load to the key through the pressing force transmit member when the key is depressed.

2. The keyboard device according to claim **1**, wherein the first shafts are formed as a unitary shaft extending along a direction in which the plurality of keys are arranged.

3. The keyboard device according to claim **2**, wherein the pressing force transmit member has a slit formed therein along a direction pointing towards a first end of the pressing force transmit member, and is inserted to the first shaft from a direction perpendicular to a direction in which the first shaft extends.

4. The keyboard device according to claim 2,

wherein the pressing force transmit member has, at a center thereof, an engaging hole that engages the first shaft, and

wherein the pressing force transmit member has an opened passage extending from the engaging hole to an exterior through which the first shaft is inserted.

5. The keyboard device according to claim 2, wherein the first shaft has a guiding portion that prevents the pressing force transmit member from oscillating in a direction parallel to the first shaft.

6. The keyboard device according to claim 1, further comprising:

a rail disposed along a direction in which the plurality of keys are arranged, the first shafts being attached to the rail.

7. The keyboard device according to claim 6, further comprising:

a plurality of brackets provided on locations prescribed along an entire length of the plurality of keys in the direction in which the plurality of keys are arranged, said plurality of brackets supporting the rail.

8. A keyboard instrument, comprising:

the keyboard device according to claim 1;

a plurality of switches respectively provided for the plurality of keys of the keyboard device according to claim 1, each switch generating an ON signal by being depressed in response to the swinging of the corresponding hammer; and

a sound source that generates a sound signal in response to the ON signal provided by the switch.

9. The keyboard instrument according to claim 8, further comprising:

a switch rail extending across an entire length of the plurality of keys in a direction in which the plurality of keys are arranged, said switch rail having the plurality of switches provided thereon such that the plurality of switches respectively correspond to the hammers.

10. The keyboard device according to claim 1, wherein the second shafts are formed as a unitary shaft extending along a direction in which the plurality of keys are arranged.

11. The keyboard device according to claim 10,

wherein the hammer has a hammer butt that couples with the second shaft, and a hammer head at a side opposite to the hammer butt, and

wherein the hammer butt has a slit formed therein along a direction pointing towards the hammer head of the hammer, and is inserted to the second shaft from a direction perpendicular to a direction in which the second shaft extends.

12. The keyboard device according to claim 11,

wherein the hammer butt of the hammer has, at a center thereof, an engaging hole that engages the second shaft, and

wherein the hammer butt has an opened passage extending from the engaging hole to an exterior through which the second shaft is inserted.

13. The keyboard device according to claim 1, wherein the second shaft has a guiding portion that prevents the hammer from oscillating in a direction parallel to the second shaft.

14. The keyboard device according to claim 1, further comprising:

a hammer rail disposed along a direction in which the plurality of keys are arranged, the second shafts being attached to the hammer rail.

15. The keyboard device according to claim 14, further comprising:

a plurality of brackets provided on locations prescribed along an entire length of the plurality of keys in the direction in which the plurality of keys are arranged, said plurality of brackets supporting the hammer rail.

16. A keyboard instrument, comprising:

the keyboard device according to claim 15;

a plurality of switches respectively provided for the plurality of keys of the keyboard device, each switch generating an ON signal by being depressed in response to the swinging of the corresponding hammer; and

a sound source that generates a sound signal in response to the ON signal provided by the switch.

17. The keyboard instrument according to claim 16, further comprising:

a switch rail having the switch provided thereon such that the plurality of switches respectively correspond to the hammers.

18. The keyboard device according to claim 1,

wherein the first shaft is stationary and has a circular cross-section with flattened sides, and the first shaft has a center defining an axis of rotation for the pressing force transmit member,

wherein the pressing force transmit member has a C-shaped receptacle that is semicircular in cross section, and an opening that is sized for insertion of the C-shaped receptacle over the flattened sides of the first shaft so that, when the C-shaped receptacle and the pressing force transmit member are rotated, the first shaft and the C-shaped receptacle are held together,

wherein the second shaft is stationary and has a circular cross-section with flattened sides, and the second shaft has a center defining an axis of rotation for the hammer, and

wherein the hammer butt of the hammer has a C-shaped receptacle that is semicircular in cross section, and an opening that is sized for insertion of the C-shaped receptacle over the flattened sides of the second shaft so that, when the C-shaped receptacle and the hammer are rotated, the second shaft and the C-shaped receptacle of the hammer are held together.

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